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Airflow separation effects on the surface stress and TKE production over wind-driven waves

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We present detailed airflow measurements taken in the laboratory for 17 different wind-wave conditions with wave ages C_p/u_* ranging from 1.4 to 66.7. For these experiments, a combined Particle Image Velocimetry (PIV) and Laser Induced Fluorescence (LIF) technique was developed. Two-dimensional airflow velocity fields were obtained as low as within the viscous sublayer on the air-side of the air-water interface. In this talk, we first examine the distribution of the surface viscous stress along the dominant wave shape. Then, using wave phase averages, we extract turbulent fields from the instantaneous measurements. In the second part of the talk, we focus on the Reynolds stress and Turbulent Kinetic Energy (TKE)producion near the interface and the role of the surface waves. In the turbulence, low horizontal velocity air is ejected away from the surface, and high velocity fluid is swept downward. The resulting quadrant analysis shows that such positive turbulent momentum flux events dominate the turbulent boundary layer. Airflow separation is observed above young wind waves ($C_p/u_* < 3.7$) and the resulting spanwise vorticity layers detached from the surface, produce intense wave coherent turbulence. Compared with classical flat plate turbulent boundary layer, additional terms in the TKE production scale with the wave slope.